Cluster Cosmology in the Next Decade: Systematics

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Snowmass on the Mississippi
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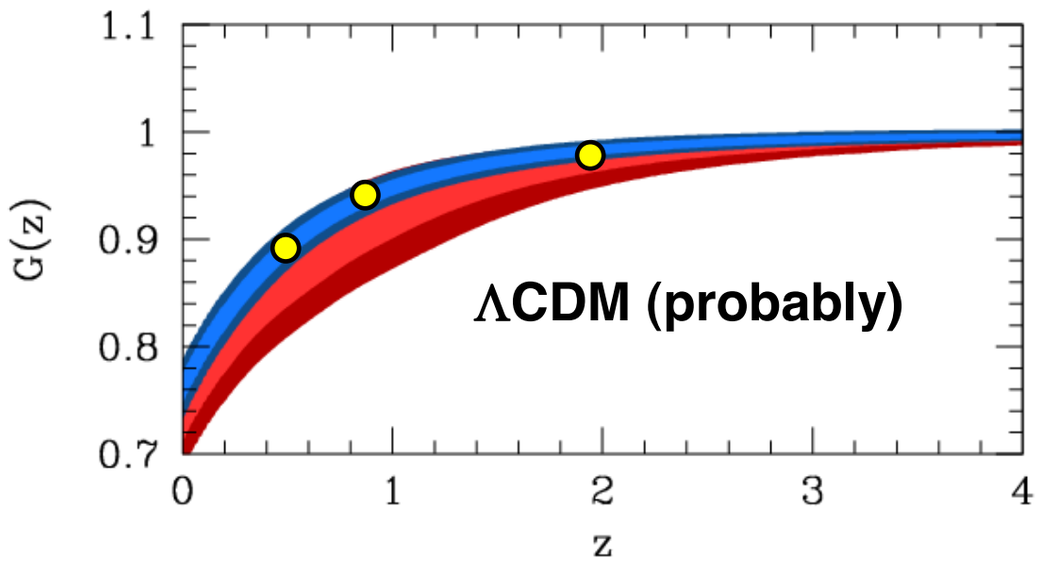
w/ Eduardo Rozo and many others

Outline

- What can clusters do?
- Advantages of using clusters to probe growth of structure
- Systematics
  - WL mass calibration
  - Galaxy colors + photo-z biases
  - Cluster centering
  - Modeling uncertainties

What Can Clusters Do?

- Excellent probes of Growth of Structure
- Clusters can falsify DE + GR



ΛCDM

quintessence

(68 / 95% CL)

Mortonson et al. (2009, 2010)
cluster predictions: Mortonson et al. (2011)
WL predictions: Vanderveld et al. (2012)

How Does it Work?

- Measure abundance function as function of mass and redshift
- Compare to geometric probes (SN, BAO, etc.)
- Voila!

- If only life were so easy...

Cluster Advantages

- Very massive ("the most massive gravitationally bound structures in the Universe")
  - Majority of signal comes from relatively low-mass clusters
- Rich in galaxies and observables
  - Optical galaxy counting + precise photo-zs
  - Spectroscopy
  - WL shear of background galaxies
  - X-ray measurements
  - SZ detections

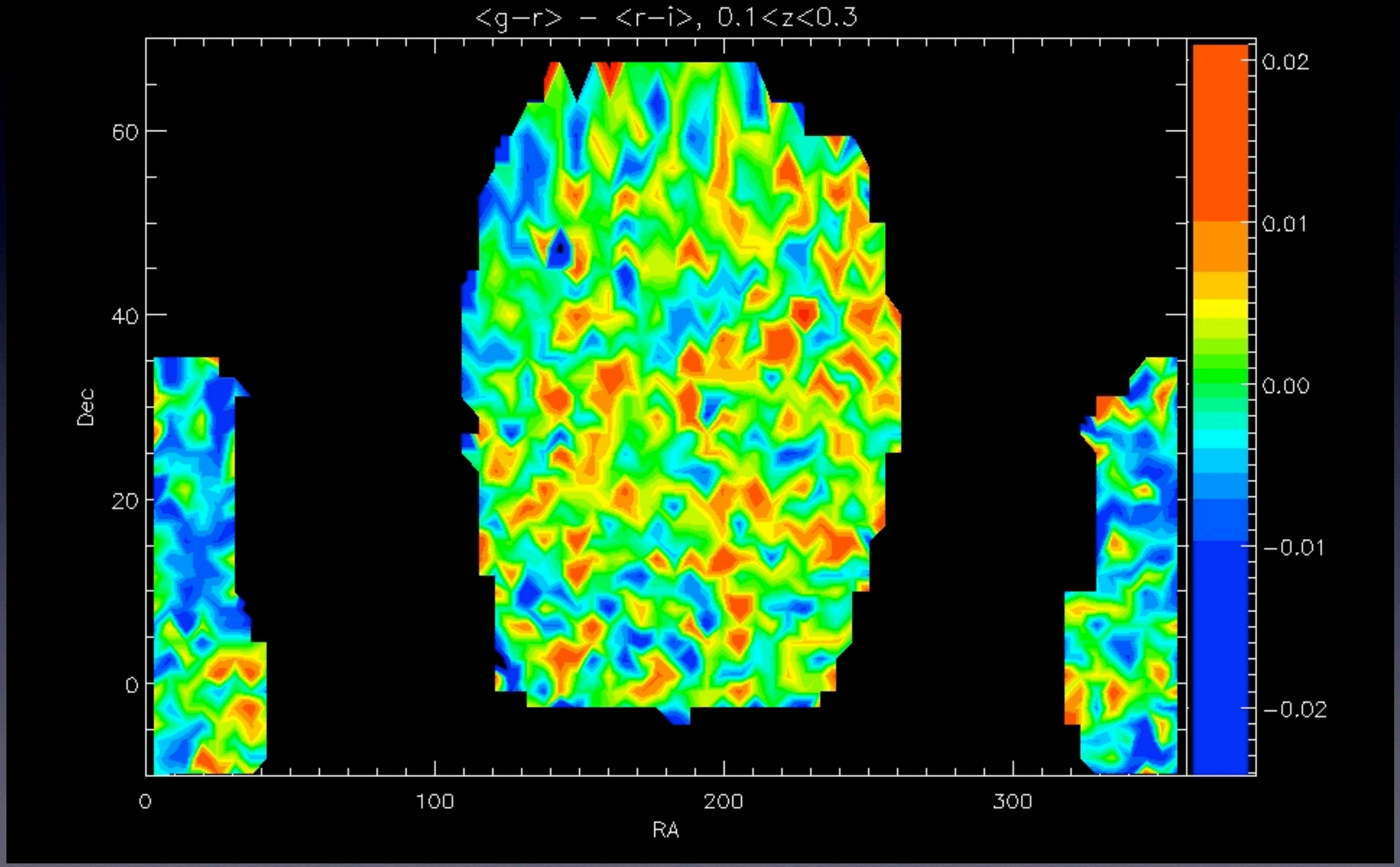
Cluster Systematics

- #1: Mass Measurements
  - Require 2% mass precision for Stage IV for 0.9% precision in σ_8
  - Can WL shear-based masses achieve this?
    - Shear biases (easier than cosmic shear)
    - Photo-z biases in background galaxies
  - Spectroscopic cross-correlation helps
- Note that currently ~7% mass calibration is achieved, but 20% offsets between different analyses!

Optical Systematics

- But that's not all...
- How do you measure galaxy colors?
  - This is not a settled question
  - Bright galaxies/faint galaxies
  - Color gradients
  - Different seeing in different bands
    - Kolmogorov (FWHM ~ $\lambda^{-0.2}$)
    - Bands taken in dark/bright time will be correlated based on obs. time
- 1% relative photometry yes...how far down can we push this?
  - Extensive LSST sim work

SDSS Relative Colors



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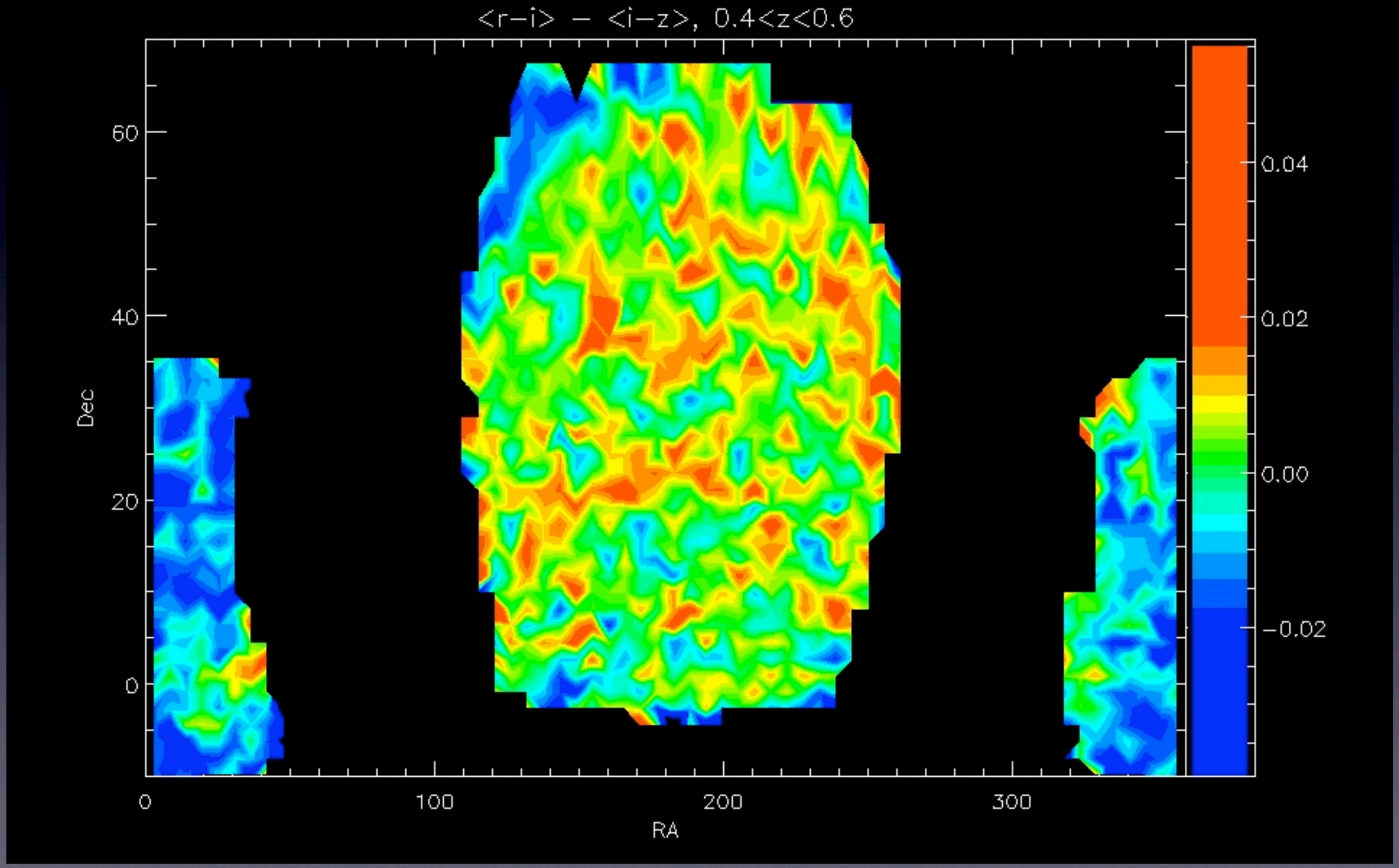

Optical Systematics

- Galactic Reddening
  - An incorrect reddening law creates photo-z biases (significant in SDSS!)
  - Uncertainties in the amplitude of the reddening correction may wash out faint signals (Cunha+2013)
- Do we require full spectroscopic coverage?

Optical Systematics

- Cluster Centering (optical + SZ clusters)
  - WL mass measurements require tangential shear around a center
  - Where is the halo center? What about merging systems?
  - X-ray data can calibrate systematic
  - Can it be controlled at the sub-percent level?

X-Ray

- Hydrostatic mass bias uncertainty
  - 0%, 10%, 20%, 40% biases have all been claimed in the literature, via both theory and observations
  - Other cross-calibration (Chandra vs XMM) issues are still present
  - WL mass calibration helps
- X-ray masses remain the lowest scatter mass proxies (even if biased)
- Key part of any multi-wavelength cluster analysis

Modeling Systematics

- Analyses up to now have used a simple log-normal powerlaw model (w/ covariance) for all scaling relations
  - Add in projection effects into model (near term)
  - Is the shape of richness-mass relation truly log-normal? How does it evolve with redshift? What astrophysics impact this?
  - High resolution X-ray studies